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STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EEL1196 – INSTRUMENTATION & MEASUREMENT TECHNIQUES
(All Sections / Groups)

08 MARCH 2019
9:00 A.M – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 5 pages including cover page with 4 Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) The mass of an object is 12.25kg. A student uses 2 different mass scales to perform the mass measurements and the readings obtained are as below:

Scale A: 12.50, 12.51 and 12.50kg
Scale B: 12.35, 12.37 and 12.32kg

Compare the accuracy and precision of each scale. Justify your answer.

[4 marks]

(b) Three inductors are connected from points A to B as shown in **Figure Q1b**. The values of the inductances are as given below:

$$L_1 = 5\mu H \pm 10\%, L_2 = 10\mu H \pm 5\%, L_3 = 1\mu H \pm 3\%$$

Calculate the total inductance between points A and B and its percentage relative limiting error. If the inductances in **Figure Q1b** are placed in a circuit with frequency, $f = 50Hz \pm 2\%$, determine the total reactance and its percentage relative limiting error.   [12 marks]
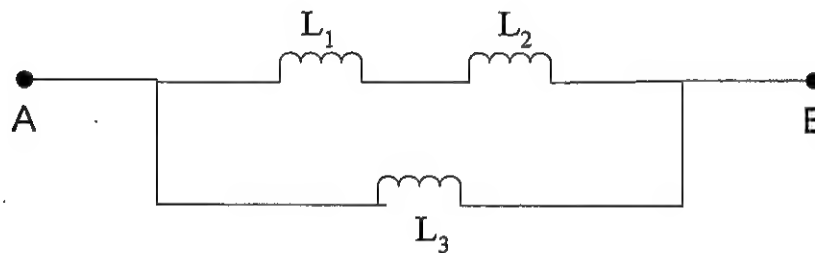

Figure Q1(b)

(c) Gross errors may be attributed to human mistakes while reading instruments, recording or calculating the measurement results. Suggest 2 ways to overcome this type of error.   [4 marks]

(d) The thermal voltage is the characteristic voltage of a semiconductor (in Volts) and is given by the following equation:
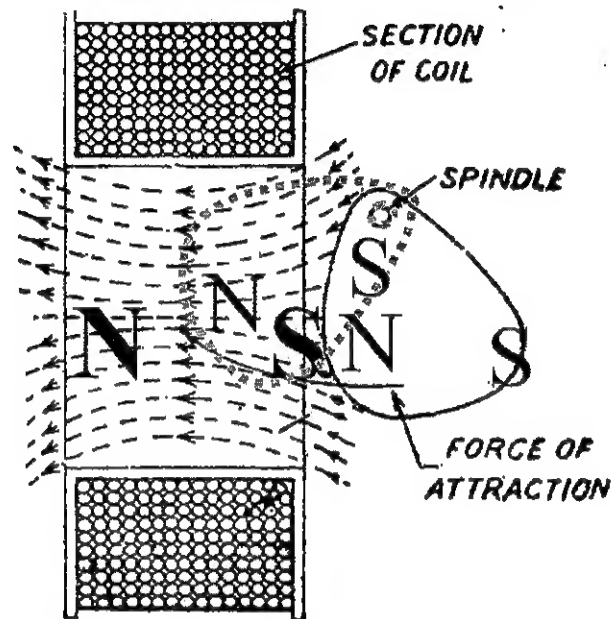
$$V_T = \frac{kT}{q}$$

where T is the temperature (in Kelvins), q is the charge (in Coulombs) and k is Boltzmann's constant. Find the dimension of k and prove that the unit of k is Joules per unit Kelvin (J/K).   [5 marks]

Continued...

Question 2

(a) The deflection torque, T_d of an instrument is proportional to square root of the current. If the instrument utilizes spring control and a current of 4A produces deflection of 30°, what will be the required current to produce a deflection angle of 45°?   [5 marks]

(b) With the aid of the diagram in **Figure Q2(b)**, explain the principle of operation of an attraction type moving iron instrument.   [8 marks]

Figure Q2(b)

(c) A fluxmeter is a special form of ballistic galvanometer, describe the two differences between the two. Then state the advantage of a fluxmeter over a ballistic galvanometer.   [4 marks]

(d) A fluxmeter is showing a 30 divisions difference between two successive deflections, it has 10 turns of search coil and an area of 40 cm². Calculate the change of flux linkages of the search coil if the produced flux density is 0.1 Wb/m². Assume that the air damping effect and the resistance, both are small.   [8 marks]

Continued...

Question 3

a) A Wheatstone bridge is shown in **Figure Q3(a)**. This bridge circuit is however unbalanced, the values of the resistors are given as $R_1 = 6k\Omega, R_2 = 25k\Omega, R_3 = 3k\Omega$ and $R_4 = 15k\Omega$. If the supply voltage is 20 V, calculate the offset voltage if a high-impedance voltmeter instrument is used.   [4 Marks]
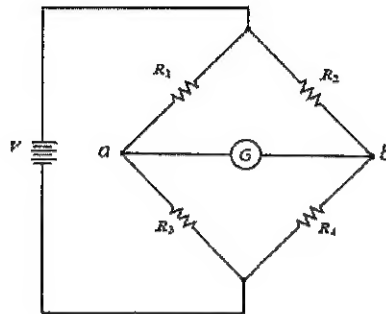

Figure Q3(a)

b) For the Series Resistance-Capacitance Bridge shown in **Figure Q3(b)**, the bridge is balanced when $R_1 = 1k\Omega$, $C_1 = 50\mu F$, $R_3 = 4k\Omega$ and $R_4 = 20k\Omega$ at a supply frequency of 100Hz. Find the unknown values for the capacitor (C_s) and resistor (R_s), then calculate its dissipation factor (*D-factor*).   [8 Marks]
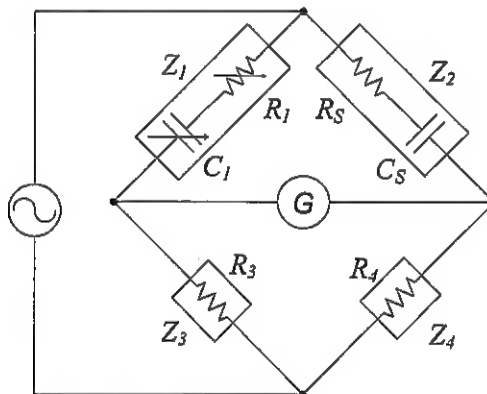

Figure Q3(b)

c) With a neat sketch of a Maxwell-Wien Bridge circuit, briefly explain the function of a Maxwell-Wien Bridge and derive the equations for the resistive and inductive components of the measured inductor.   [13 Marks]

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Question 4

(a) A wattmeter is connected to measure power in a single phase circuit as shown in **Figure Q4(a)**, whereby the moving coil (pressure coil) is connected after the fixed coil (current coil). Prove that the wattmeter reading will be equal to the sum of the load power and the loss in the pressure coil:

$$Wattmeter\ reading = Load\ power + Loss\ in\ pressure\ coil = P_L + \frac{V_L{}^2}{R_P}$$

where V_L is the load voltage and R_P is the resistance of the moving coil. Hence, calculate the % error of the wattmeter reading if the load current is 3A and $V_L = 200V$ with a power factor of 0.9. Given $R_P = 3.6k\Omega$.   [7 marks]
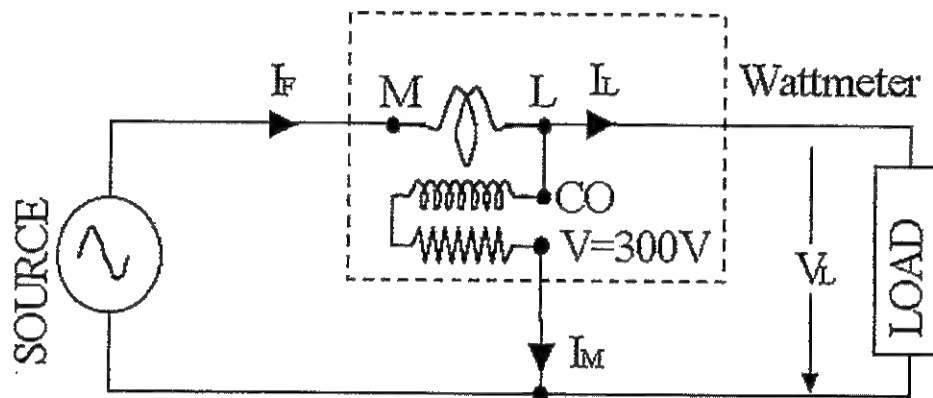

Figure Q4(a)

(b) The power input in a 3-phase circuit is measured by two wattmeters. If the total power is 20kW and the difference between the two wattmeter readings is 5kW,

     (i) What is the reading of each wattmeter?   [2 marks]

     (ii) Determine the power factor of the load if $V_L = 400V$ and $I_L = 30A$.
         [2 marks]

     (iii) Is the load purely resistive? Justify your answer.   [2 marks]

(c) Describe the difference between passive transducers and active transducers, give one example for each type, then briefly explain the workings of your example transducers.   [4 marks]

(d) To measure the air pressure difference between two experimental chambers with different air pressures, a diaphragm is used, the effective area of the diaphragm is $60\ cm^2$. If the force exerted on the diaphragm was found to be 120N, find the air pressure difference between the two chambers in psi. (1 Pascal $= 1.45 \times 10^{-4}$ psi).   [8 marks]

End of Paper